REMARKS

In response to the Official Action mailed on March 27, 2006, the application has been amended. No new matter has been added. Reconsideration of the rejections of the claims is respectfully requested in view of the above amendments and the following remarks.

On page 2 of the Official Action, claims 1 - 3 and 7 - 9 were rejected under 35 USC 103 as unpatentable over JP 09-019790 or JP 08-243782. This rejection is respectfully traversed.

Amended claim 1 describes a lead-free solder including at least one substance selected from 0.005 - 0.1 % of Au, 0.005 - 0.1 % of Fe, 0.005 - 0.1 % of Pt, 0.005 - 0.1 % of Pd, and 0.1 - 1 % of Sb. Amended claim 1 is supported by page 7 of the application as filed, which discloses that any of Au, Fe, Pt, Pd, and Sb may be present in an amount of 0.005 - 1.0 mass %, and by Table 1, which gives examples in which each of Au, Fe, Pt, and Pd is present in an amount of up to 0.1 % and Sb is present in an amount up to 1.0 %. Neither of the cited references discloses or suggests such a composition.

JP 09-019790 and JP 08-243782 disclose generic compositions which potentially overlap the ranges defined in claim 1, but neither of these references discloses any specific compositions satisfying the ranges defined by claim 1.

Specifically, JP 09-019790 discloses a lead-free Sn-Zn-In-Bi based soldering alloy. According to paragraph 010, the alloy may optionally contain a total of at most 2 % of Ag, Au, Cu, and Sb.

However, there is no example in this reference which actually contains any of these elements or any teaching of a suitable range for any of the individual elements.

Similarly, JP 08-243782 describes a Sn-Zn based solder alloy which may optionally contain up to 3 % of Sb, In, Au, Ag, or Cu. The only actual values given for Au and Sb are an Au content of 1% (in Example 6) and an Sb content of 2% (in Example 3), which are far outside the ranges for Au and Sb specified in claim 1.

As such, there are no teachings in these references to motivate a person skilled in the art to select an alloy containing one of Au, Fe, Pt, or Pd in the range of 0.005 - 0.1 % or Sb in the range of 0.1 - 1 % as set forth in claim 1.

Furthermore, as described in detail below, the ranges for the alloys Au, Fe, Pt, Pd, and Sb set forth in claim 1 provide unexpected effects which are totally unpredictable from the properties of the alloys set forth in JP 09-019790 or JP 08-243782. In light of these unexpected effects, the composition set forth in amended claim 1 is not obvious. Claims 1 and claims 2 - 3 and 7 - 9 which depend from it are accordingly allowable.

On page 3 of the Official Action, claims 1 - 4 and 7 - 9 were rejected under 35 USC 103 as unpatentable over JP 09-085484, JP 09-174278, or EP 0622151. This rejection is respectfully traversed.

As set forth above, amended claim 1 describes a lead-free solder including at least one substance selected from 0.005 - 0.1 % of Au, 0.005 - 0.1 % of Fe, 0.005 - 0.1 % of Pt, 0.005 - 0.1 %

of Pd, and 0.005 - 1 % of Sb. None of the cited references discloses or suggests such a composition.

JP 09-085484 discloses a lead-free Sn-Zn-Bi based solder alloy. According to paragraph 046 of this reference, the inventors studied the effects of adding small amount of Ag, Sb, Cu, and In to a Sn-5Zn-15Bi alloy. They found that the addition of Sb contributes to an improvement in mechanical properties, but nowhere is there any disclosure of the amount of Sb which was added or is considered suitable. Thus, there is nothing in this reference which suggests an Sb content of 0.005 - 1 % as set forth in claim 1.

EP 0622151 discloses a lead-free solder alloy based on a Sn-In-Zn system. Column 2, lines 14 - 18 state that the composition may contain 0 - 5 weight % of Sb and preferably at most 3 weight % of Sb, and column 2, lines 39 - 46 state that the alloy may contain minor amounts (typically a total of at most 10 weight %) of elements such as Ag, Au, or Cu, with desirable amounts of each being 0 - 5 % and preferably at most 2 weight %. However, there is no specific example of any alloy containing any of these components.

Accordingly, there is nothing in either of these references to motivate a person skilled in the art to select an alloy containing either Au or Sb in the ranges set forth in claim 1 from the generic description provided by these references.

Furthermore, the below-described unexpected effects of alloy having the composition set forth in claim 1 additionally establish the nonobviousness of this claim.

JP 09-174278 describes a lead-free alloy which contains 0.4 - 3 % of Ag as a required component. Ag is excluded from the composition of claim 1 by the transitional language "consisting of", so this reference is not relevant to claim 1.

Accordingly, since none the cited references discloses or suggests the specific compositions set forth in claim 1, they cannot render this claim obvious. Claim 1 and claims 2 - 4 and 7 - 9 which depend from it are therefore allowable.

On page 4 of the Official Action, claims 5 and 6 were rejected under 35 USC 103 as unpatentable over JP 09-085484, JP 09-174278, or EP 0622151 and further in view of JP 06-087090. This rejection is respectfully traversed.

In this rejection, JP 09-085484, JP 09-174278, and EP 0622151 were relied up as generically disclosing solder compositions overlapping the ranges set forth in claims 1 - 4 and 7 - 9, while JP 06-087090 was relied upon as teaching the use of a flux as set forth in claim 5 and 6. However, since none of JP 09-085484, JP 09-174278, or EP 0622151 discloses or suggest the alloy composition set forth in claim 1, combining these references with JP 06-087090 would still not result in a solder paste having all the features set forth in claim 1 and included in claims 5 and 6 by their dependence from claim 1. Claims 5 and 6 are therefore allowable.

In order to demonstrate the unexpected effects of a solder according to the present invention, the inventors performed a

solder spreading test on various alloys having compositions falling inside or outside the ranges defined by claim 1. In the test, a solder paste containing either Sn-9Zn-Au powder or Sn-9Zn-Sb powder with an average particle diameter of approximately 40 μm was applied by screen printing using a metal screen with a thickness of 0.15 nm to Cu lands on a printed wiring board. Attached Figure 1 illustrates the printed wiring board and the test patterns.

The printed wiring board and the solder paste were subjected to reflow in a nitrogen-atmosphere reflow furnace with a nitrogen concentration of 500 ppm. The preheating temperature was 150 °C, and the peak reflow temperature was 225 °C.

The wetting properties and spreadability of the solder on the solder spreading test patterns was evaluated. A sample was evaluated as no good (NG) if there was a prominent lack of wetting within the test pattern.

The attached photographs show the results of the spreading test. The Sn-9Zn-Sb solder paste had good wetting of the test pattern when the Sb content of the paste was 0.1 or 1.0 mass %, but the wetting was unacceptable when the Sb content was 2.0 mass % (which is an Sb content that a person skilled in the art would be encourage to use based on the disclosure of JP 08-243782, which gives an example with an Sb content of 2.0 %). The Sn-9Zn-Au solder paste had good wetting of the test pattern when the Au content of the paste was 0.01 or 0.1 mass %, but the wetting was unacceptable when the Au content was 1.0 mass % (which is an Au content that a person skilled in the art would assume to be

suitable from the disclosure in JP 08-243782, for example, which gives an example in which the Au content is 1.0 %).

Thus, the ranges for Au and Sb that the prior art would lead a person skilled in the art to employ in the alloys disclosed in the references in fact provide poor results if used in an alloy according to the present invention. An alloy according to the present invention containing Pt, Pd, or Fe in the amounts set forth in claim 1 is expected to provide the same unexpected effects as an alloy according to the present invention containing Au in an amount of 0.005 - 0.1 %.

New claims 10 - 17 describe additional features of the present invention. New claim 10 states that the alloy of claim 1 includes at least one of Pt, Pd, and Fe, while claim 11 specifies that the alloy contains Fe. None of the cited references discloses a solder alloy containing any of Pt, Pd, or Fe, so claims 10 and 11 are allowable.

New claim 12 states that the alloy of claim 1 includes 0.5 - 12 mass % of Bi but no In, new claim 13 includes at least 2 mass percent of Bi but not In, and new claim 14 includes at most 10 mass % of Bi. These claims are supported by page 8 and Table 1 of the specification as filed. The only cited reference which can contain Bi without also containing In is JP 09-085484, which requires 13 - 16 mass % of Bi, which is outside the range for Bi set forth in claims 12 - 14. Thus, none of the cited references discloses or suggest a composition as set forth in claims 12 - 14. New claims 15 - 17 are allowable as depending from claim 1.

In light of the foregoing remarks, it is believed that the present application is in condition for allowance. Favorable consideration is respectfully requested.

Respectfully submitted,

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Attachments
Figure 1 and photographs of experimental results